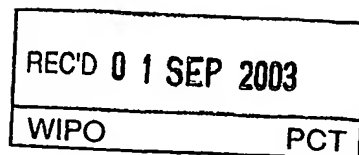


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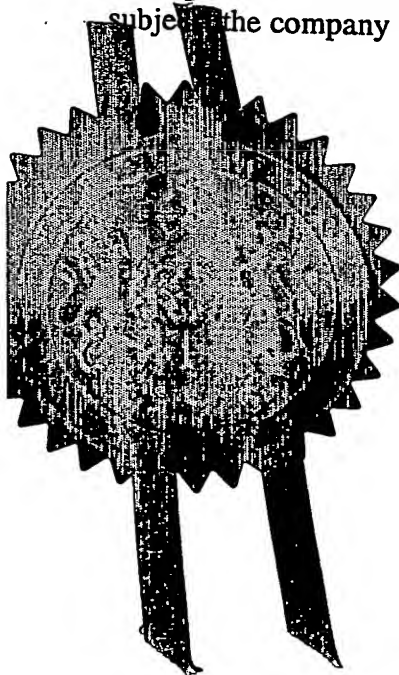
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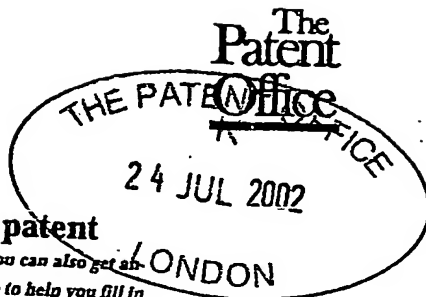
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2. Patent application number

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Patents ADP number (if you know it)  
08506040001

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114, D-40597, DUSSELDORF, GERMANY

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US AND GERMANY

08432221001

4. Title of the invention

METHOD OF DEINKING

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

ABLETT & STEBBING  
CAPARO HOUSE  
101-103 BAKER STREET  
LONDON  
W1U 6FQ

Patents ADP number (if you know it)

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Priority application number  
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Date of filing  
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Number of earlier application

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Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

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## METHOD OF DEINKING

The present invention relates to a method of deinking printed wastepaper.

5 Growing awareness of environmental damage caused by deforestation has seen an increase in the recycling of wastepaper in recent years. It has been recognised that the ability to recycle wastepaper is commercially advantageous and has a significant impact on the conservation of virgin fibre  
10 resources. However, technological advances in printing inks and print media present ever-growing challenges to recyclers.

Printing on paper is typically accomplished using one of two types of ink, namely, impact ink, which is physically pressed onto the paper, and non-impact ink, which is attracted  
15 to a charged image and is then transferred to the paper. Impact inks are typically wet inks, for example letterpress inks, offset litho inks, photogravure inks and flexographic inks. For example, letterpress inks are generally composed of carbon black pigment in a mineral oil vehicle and are used  
20 in, for example, newspaper printing. Offset litho inks tend to contain more pigment than letterpress inks and contain drying oils such as linseed or alkyl resins. Flexographic inks are used in similar processes to letterpress inks but are water-based and contain emulsified ink in an alkali soluble  
25 binder. Such inks may easily be dislodged, but may form extremely fine particles that are difficult to capture and remove.

Non-impact inks, e.g. toners, are generally dry, powdered inks and are used in laser printing, photocopying and  
30 facsimile machines and generally comprise thermoplastic resins and pigment.

The deinking of paper bearing these two different types of ink requires different deinking procedures and conditions.

Conventionally, deinking of paper bearing non-impact ink merely requires pulping with a surfactant in neutral conditions, whereas paper bearing impact ink requires different conditions, such as treatment with alkali, silicate  
5 and peroxide, as well as a surfactant.

---

In conventional deinking methods, the wastepaper is disintegrated (pulped) by mechanical agitation in an aqueous medium to separate the ink and impurities from the paper fibre and disintegrate the ink into particles of approximately 0.1  
10 to 1000  $\mu\text{m}$ . A grey slurry is thus obtained in which the ink is present in a finely dispersed form. The impurities, for example, plastic, aluminium foil, stones, screws, staples, paper clips etc., are removed during a large number of screening steps.

15        Whilst ink detachment of non-impact, e.g. photocopy, paper can normally be achieved in neutral conditions, for other printed paper ink detachment is routinely accomplished at alkaline pH levels using alkali hydroxides, alkali silicates, oxidative-working bleaches and surfactants at  
20 temperatures between 30 and 50°C. Usually, anionic and nonionic tensides are used as surfactants, for example, soaps, ethoxylated fatty alcohols and/or ethoxylated alkyl phenols (see, for example, EP 0013758).

The ink particles are then removed from the fibre slurry  
25 by washing and/or flotation. Smaller ink particles are removed by washing, and larger ink particles and stickies (i.e. glue residues and adhesives) are removed by flotation. During flotation, air bubbles are blown into the pulp. The dispersed ink particles become attached to the air bubbles,  
30 which carry the ink particles to the surface. The resultant foam is then skimmed from the surface. Subsequent steps involve heating the pulp to evenly distribute stubborn ink particles and screening the pulp to separate the damaged,

short or weak fibres. The remaining clean pulp is then pressed between rollers into sheets and dried.

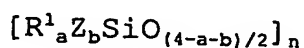
Thus, efficient deinking demands both successful separation of the ink from the paper fibre and removal of the dispersed ink from the fibre slurry.

However, there are a number of disadvantages associated with traditional deinking methods. For example, the incomplete removal of ink particles from the fibre slurry can cause the resulting paper to have a grey hue, spotting, and a low degree of brightness. Brightness and colour are important quality criteria for many paper uses.

In addition, the alkaline conditions used in traditional deinking methods cause water-soluble and/or colloidal solids and finely dispersed solids to contaminate the process water, for example, fillers, fine fibres and stickies. If these contaminants are insufficiently removed during washing, they can be concentrated by subsequent washings and reintroduced to the paper fibre, causing a loss of brightness in the resultant paper. Effluent containing the aforementioned chemicals conventionally used in deinking methods is also environmentally undesirable.

The present invention seeks to provide a method of deinking wastepaper which can overcome disadvantages of conventional deinking methods.

According to the present invention there is provided a method of deinking printed paper, the method comprising pulping the paper to form an aqueous slurry, adding a deinking additive to the paper, and removing detached ink by flotation, wherein the additive comprises an organo-modified siloxane comprising units of the formula:



in which each  $R^1$  is independently selected from a hydrogen atom, an alkyl, aryl, alkenyl, aralkyl, alkaryl, alkoxy, alkanoyloxy or hydroxyl group;

each Z is independently selected from an alkyl group  
~~5 substituted with an amine, amide, carboxyl, ester, or epoxy~~  
group, or a group  $-R^2-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^3$ ;

n is an integer greater than 1;

a and b are independently 0, 1, 2 or 3;

$R^2$  is an alkylene group or a direct bond;

10  $R^3$  is a group as defined for  $R^1$  or Z above;

p and r are independently an integer from 1 to 6;

q and s are independently 0 or an integer such that  
 $1 \leq q + s \leq 400$ ;

and wherein each molecule of the organo-modified siloxane  
15 contains at least one group Z.

Z is preferably a group  $-R^2-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^3$ , more preferably wherein p and/or r are independently 2, 3 or 4, i.e. a group comprising ethylene, propylene, and/or butylene oxide groups. Preferably, q and s are each independently  
20 integers from 10 to 30, more preferably 15 to 25 (for example 18). In a particularly preferred group Z, p is 2, r is 3, and q and s are both 18.  $R^2$  may be an alkylene group, for example having from 1 to 6 carbon atoms (i.e. a methylene, ethylene, propylene, butylene, pentylene or hexylene group), or a direct  
25 bond.  $R^3$  may be a group as defined hereinabove for  $R^1$  or Z, and is preferably a hydrogen atom or a hydroxyl group.

Additionally or alternatively, Z may be an alkyl group substituted with an amine, amide, carboxyl, ester, or epoxy group, for example an alkyl group having from 1 to 6 carbon  
30 atoms, i.e. a substituted methyl, ethyl, propyl, butyl, pentyl or hexyl group.

The siloxane may be linear or may comprise units in which  $a + b = 0$  or 1, i.e. the siloxane may contain branching. The

siloxane is preferably hydroxyl or alkanoyloxy endcapped, i.e. in a unit in which a is 1, 2 or 3 and  $a + b = 3$ , at least one  $R^1$  is  $-OH$  or  $-O(C=O)CH_3$  in that unit.

Preferably, 2 to 20 mole percent of silicon atoms in the 5 siloxane molecule are substituted by a group Z, more preferably 5 to 16 mole percent.

The siloxane preferably has a hydrophilic/lipophilic balance (HLB) in the range of 5.0 to 7.3.

The molecular weight of the siloxane is preferably in the 10 range of 1,000 to 500,000, more preferably 20,000 to 100,000.

A particularly preferred siloxane for use in the present invention is a hydroxy-endcapped linear polydimethylsiloxane having a molecular weight of from 58,000 to 62,000 and an HLB of 5.9 to 6.3, in which 10 to 12 mole percent of silicon atoms 15 are substituted by Z groups of the formula  $-R^2-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^3$ , in which p is 2, r is 3 and q and s are both 18,  $R^2$  is an alkylene group having from 1 to 6 carbon atoms or a direct bond, and  $R^3$  is a hydrogen atom or hydroxyl group.

20 The additive used in the present invention may comprise further components, in addition to the organo-modified siloxane. For example, the additive may further comprise one or more components selected from a polydimethylsiloxane, an organic polyether, and a fatty acid. Suitable organic 25 polyethers include those of the formula  $R^4-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^5$  in which  $R^4$  and  $R^5$  are selected from a hydrogen atom, hydroxyl, alkyl and alkoxy groups, and p, q, r and s are as defined hereinabove. Suitable fatty acids include saturated and unsaturated monobasic aliphatic carboxylic acids, for 30 example having from 8 to 22 carbon atoms, such as lauric, myristic, palmitic, stearic, arachidic, behenic, lignoceric, palmitolic, oleic, linoleic, linolenic, and arachidonic acids.

The additive may be in the form of an emulsion, for



example the organo-modified siloxane may be a gum based self-emulsifying siloxane.

In the method of the present invention, the additive may be added to the paper before, during or after pulping. The  
~~5 amount of additive to be added to the paper is preferably~~  
within the range 0.1 to 1 wt% of the paper, more preferably 0.1 to 0.5 wt%. The additive may, for example, be added to the paper neat, as an emulsion, or in solution, for example an aqueous solution.

10 The method of the present invention is preferably performed at substantially neutral pH, although the method may be performed under alkaline pH.

The pulping and ink removal steps of the present invention may be performed as is conventional, as will be  
15 familiar to a person skilled in the art and described hereinabove. For example, the paper may be pulped to form an aqueous slurry having a consistency of, for example, from 1 to 10% (for example, 1 to 5%) at a temperature of between 30 and 50°C, for example 35 to 45°C. Consistency is defined as  
20 wt% of pulp solids in the fibre suspension. Ink removal may be performed in a suitable flotation cell (for example, a Denver Lab flotation cell) at a suitable temperature, for example between 30 and 50°C (e.g. 35 to 45°C), and number of revolutions per minute, for example from 500 to 1000 rpm.

25 Embodiments of the present invention will now be described in detail.

#### Example 1

##### a) Pulping

30 To an aqueous suspension of 110g of air-dry wastepaper (50% newspaper and 50% magazine paper) having a consistency of 4% were added 440g of industrial water at 45°C in a mixing vessel. The suspended paper was kneaded for 15 minutes at

45°C.

b) Ink removal

Water having a hardness of 16°dH was added to the pulp obtained in a) above to achieve a consistency of 1%. To the 5 pulp varying amounts of a hydroxyl endcapped polydimethylsiloxane having approximately 11 mole % silicon atom substitution by  $-(OC_2H_4)_{18}(OC_3H_6)_{18}$  side chains, an HLB of approximately 6.1 and a molecular weight of approximately 60,000 (referred to herein as Siloxane 1) was added as an 10 aqueous solution. The pulp was floated for 8 minutes at 45°C in a Denver Lab Flotation Cell at 1000 rpm, after which the pulp was separated from the water, and formed into sheets between two filters of a sheet former with drying at 95°C for 10 minutes under vacuum.

15 By way of comparison, steps a) and b) above were repeated using a commercially available fatty acid based deinking preparation. The results are shown in Table 1 below. Whiteness was evaluated according to DIN 53145 Part 1.

Table 1

Additive	wt % of additive used	Paper	pH	Whiteness before flotation %	Whiteness after flotation %	Whiteness difference %
Fatty acid	0.4	aged	8.5	42.4	59.0	16.6
Fatty acid	0.4	fresh	7.2	43.6	51.3	7.7
Siloxane 1	0.3	aged	8.5	46.6	61.9	15.3
Siloxane 1	0.3	fresh	8.5	46.6	61.9	15.3
Siloxane 1	0.3	fresh	7.2	46.5	59.1	12.6
Siloxane 1	0.1	fresh	7.2	44.6	56.5	11.9
Siloxane 1	0.3	aged	7.2	40.2	47.8	7.6

Example 2

a) Pulping

To an aqueous suspension of 110g of air-dry wastepaper (10% newspaper and 90% magazine paper) having a consistency of 20% were added 440ml of industrial water at 45°C in a mixing vessel. The suspended paper was kneaded for 15 minutes at 45°C.

b) Ink removal

Water was added to the pulp obtained in a) above to achieve a consistency of 1.09%. To the pulp varying amounts of a hydroxyl endcapped siloxane as defined in Table 4 below were added as an aqueous solution. The pulp was floated for 8 minutes at 45°C in a Denver Lab Flotation Cell.

Steps a) and b) above were repeated using the siloxane used in Example 1 (Siloxane 1) and the siloxanes defined in Table 4 (Siloxanes 2 to 8) on fresh and aged wastepaper. Table 4 also contains viscosity data for each of the siloxanes. By way of comparison, the experiment was also carried out using the commercially available fatty acid based deinking preparation used in Example 1. The results are shown in Table 2 (fresh wastepaper) and Table 3 (aged wastepaper) below. Whiteness was evaluated according to DIN 53145 Part 1.

Table 2

Additive	wt % of additive used	pH	Whiteness before flotation %	Whiteness after flotation %	Whiteness difference %
Fatty acid	0.4	8.1	35.8	51.1	15.3
Siloxane 1	0.3	7.5	39.4	56.5	17.1
Siloxane 2	0.3	7.5	39.1	54.2	15.1
Siloxane 3	0.3	7.5	40.2	55.0	14.8
Siloxane 4	0.3	7.5	37.8	55.0	17.2
Siloxane 5	0.3	7.5	39.0	52.6	13.6
Siloxane 6	0.3	7.5	41.2	53.5	12.3
Siloxane 7	0.3	7.5	39.5	57.1	17.6
Siloxane 8	0.3	7.5	40.1	54.0	13.9

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Table 3

Additive	wt % of additive used	pH	Whiteness before flotation %	Whiteness after flotation %	Whiteness difference %
Fatty acid	0.4	7.8	36.3	44.6	8.3
Siloxane 1	0.3	7.3	37.0	47.8	10.8
Siloxane 4	0.3	7.3	37.0	50.3	13.3
Siloxane 7	0.3	7.3	37.5	48.0	10.5

5

Table 4

n (degree of polymerisation)	% Substituted Silicon atoms		
	5	10	15
100	Siloxane 2 7,720 cP	Siloxane 3 5,560 cP	Siloxane 4 3,100 cP
300	Siloxane 5 98,540 cSt	Siloxane 6 6,060 cP	Siloxane 7 5,090 cP
500			Siloxane 8 6,830 cP

10

15

Example 3

a) Pulping

To an aqueous suspension of 110g of air-dry wastepaper (100% newspaper) having a consistency of 20% were added 400ml  
5 of industrial water at 45°C in a mixing vessel. The suspended paper was kneaded for 15 minutes at 45°C.

b) Ink removal

Water was added to the pulp obtained in a) above to achieve a consistency of 1.09%. To the pulp varying amounts  
10 of a hydroxyl endcapped siloxane as defined in Table 4 and Example 1 were added as an aqueous solution. The pulp was floated for 8 minutes at 45°C in a Denver Lab Flotation Cell.

Steps a) and b) above were repeated using the siloxane used in Example 1 (Siloxane 1) and two of the siloxanes  
15 defined in Table 4 (Siloxanes 4 and 7). By way of comparison, the experiment was also carried out using the commercially available fatty acid based deinking preparation used in Example 1. The results are shown in Table 5 below. Whiteness was evaluated according to DIN 53145 Part 1.

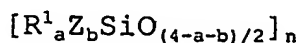
Table 5

Additive	wt % of additive used	pH	Whiteness. before flotation %	Whiteness after flotation %	Whiteness difference %
Fatty acid	0.4	7.7	24.7	27.0	2.3
Siloxane 1	0.3	7.3	26.5	33.0	6.5
Siloxane 4	0.3	7.2	24.4	33.0	8.6
Siloxane 7	0.3	7.3	26.0	35.0	9.0



CLAIMS

1. A method of deinking printed paper, the method comprising pulping the paper to form an aqueous slurry, adding a deinking  
~~5 additive to the paper, and removing detached ink by flotation,~~  
wherein the additive comprises an organo-modified siloxane comprising units of the formula:



10

in which each  $R^1$  is independently selected from a hydrogen atom, an alkyl, aryl, alkenyl, aralkyl, alkaryl, alkoxy, alkanoyloxy or hydroxyl group;

each Z is independently selected from an alkyl group  
15 substituted with an amine, amide, carboxyl, ester, or epoxy group, or a group  $-R^2-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^3$ ;

n is an integer greater than 1;

a and b are independently 0, 1, 2 or 3;

$R^2$  is an alkylene group or a direct bond;

20  $R^3$  is a group as defined for  $R^1$  or Z above;

p and r are independently an integer from 1 to 6;

q and s are independently 0 or an integer such that  
 $1 \leq q + s \leq 400$ ;

and wherein each molecule of the organo-modified siloxane  
25 contains at least one group Z.

2. A method according to claim 1 wherein Z is a group  
 $-R^2-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^3$ .

30 3. A method according to claim 2 wherein p and/or r are independently 2, 3 or 4.

4. A method according to claim 2 or 3 wherein q and s are

each independently integers from 10 to 30.

5. A method according to claim 4 wherein q and s are each independently 15 to 25.

5

6. A method according to any one of claims 2 to 5 wherein p is 2, r is 3, and q and s are both 18.

7. A method according to any preceding claim wherein R<sup>2</sup> is  
10 a methylene, ethylene, propylene, butylene, pentylene or hexylene group.

8. A method according to any preceding claim wherein R<sup>3</sup> is a hydrogen atom or a hydroxyl group.

15

9. A method according to any preceding claim wherein the siloxane is linear.

10. A method according to any preceding claim wherein the  
20 siloxane contains branching.

11. A method according to any preceding claim wherein the siloxane is hydroxyl or alkanoyloxy endcapped.

25 12. A method according to any preceding claim wherein 2 to 20 mole percent of silicon atoms in the siloxane molecule are substituted by a group Z.

13. A method according to claim 12 wherein 5 to 16 mole  
30 percent of silicon atoms in the siloxane molecule are substituted by a group Z.

14. A method according to any preceding claim wherein the

siloxane has a hydrophilic/lipophilic balance (HLB) in the range of 5.0 to 7.3.

15. A method according to any preceding claim wherein the  
~~5 siloxane has a molecular weight in the range of 1,000 to~~  
500,000.

16. A method according to claim 15 wherein the siloxane has a molecular weight in the range of 20,000 to 100,000.

10

17. A method according to any preceding claim wherein the siloxane is a hydroxy- $\alpha$ -capped linear polydimethylsiloxane having a molecular weight of from 58,000 to 62,000 and an HLB of 5.9 to 6.3, in which 10 to 12 mole percent of silicon atoms  
15 are substituted by Z groups of the formula  $-R^2-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^3$ , in which p is 2, r is 3 and q and s are both 18,  $R^2$  is an alkylene group having from 1 to 6 carbon atoms or a direct bond, and  $R^3$  is a hydrogen atom or hydroxyl group.

20

18. A method according to any preceding claim wherein the additive further comprises one or more components selected from a polydimethylsiloxane, an organic polyether, and a fatty acid.

25

19. A method according to claim 18 wherein the additive further comprises an organic polyether of the formula  $R^4-(OC_pH_{2p})_q(OC_rH_{2r})_s-R^5$  in which  $R^4$  and  $R^5$  are selected from a hydrogen atom, hydroxyl, alkyl and alkoxy groups, p and r are  
30 independently an integer from 1 to 6, and q and s are independently 0 or an integer such that  $1 \leq q + s \leq 400$ .

20. A method according to claim 18 or 19 wherein the additive

further comprises a fatty acid which is a saturated or unsaturated monobasic aliphatic carboxylic acid.

21. A method according to claim 20 wherein the carboxylic  
5 acid is selected from lauric, myristic, palmitic, stearic, arachidic, behenic, lignoceric, palmitolic, oleic, linoleic, linolenic, and arachidonic acids.

22. A method according to any preceding claim wherein the  
10 additive is an emulsion.

23. A method according to claim 22 wherein the additive is a gum based self-emulsifying siloxane.

15 24. A method according to any preceding claim wherein the additive is added to the paper in an amount within the range 0.1 to 1 wt% of the paper.

25. A method according to claim 24 wherein the additive is  
20 added to the paper in an amount within the range 0.1 to 0.5 wt% of the paper.

26. A method according to any preceding claim which is performed at substantially neutral pH.

25

27. A method substantially as hereinbefore described.

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